(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 May 2001 (25.05.2001)

PCT

(10) International Publication Number
WO 01/37207 A1

(51) International Patent Classification[7]: G06K 9/00, B05D 5/00, G03C 3/00

(21) International Application Number: PCT/US00/42065

(22) International Filing Date:
9 November 2000 (09.11.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/164,387 9 November 1999 (09.11.1999) US
09/708,273 8 November 2000 (08.11.2000) US

(71) Applicant: SPECTRA SCIENCE CORPORATION [US/US]; Suite 102, 321 South Main Street, Providence, RI 02903 (US).

(72) Inventor: LAWANDY, Nabil, M.; 169 Eastwick Road, North Kingstown, RI 02852 (US).

(74) Agent: SMITH, Harry, F.; Ohlandt, Greeley, Ruggiero & Perle, L.L.P., 10th floor, One Landmark Square, Stamford, CT 06901-2682 (US).

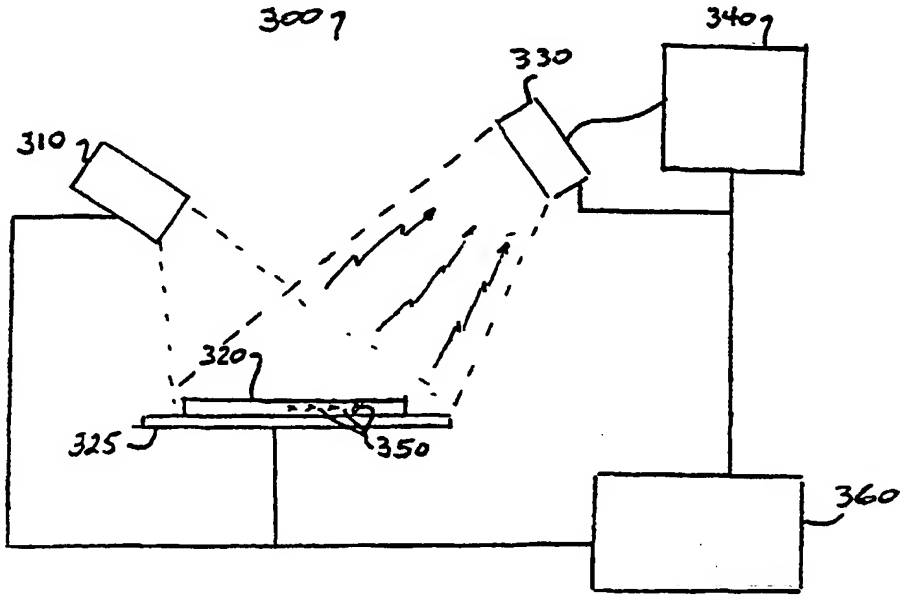
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

[Continued on next page]

(54) Title: AUTHENTICATION AND CODING BY SIZE, SHAPE, AND FLUORESCENCE



(57) Abstract: A method provides information concerning an object, and includes steps of providing the object (230) and encoding information concerning the object by providing a set of taggants (350) in association with the object. The set of taggants contains members having distinguishing physical attributes which may include at least one of color, emission wavelength, size, shape and loading factor which, in combination, are predetermined for encoding information regarding the object. Further steps detect the physical attributes (330) and decode the information from the detected physical attributes. The set of taggants can include at least one of particles, fibers and planchets.

WO 01/37207 A1

— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

AUTHENTICATION AND CODING BY SIZE, SHAPE, AND FLUORESCENCE

FIELD OF THE INVENTION:

This invention relates to a method and apparatus for providing reliable and repeatable identification, authentication and coding of an object by using at least one of the size, shape or loading (density per unit area) of encoding materials (taggants), either alone or in combination with a fluorescent emission of the taggants.

BACKGROUND OF THE INVENTION:

It is well known that valuable items, for example, negotiable instruments, art work, etc. are susceptible to theft and counterfeiting. With regard to documents, the advancement of color copier technology has made it fairly easy to create a color copy of any document, including currency, using commonly available equipment.

In an effort to stem widespread counterfeiting of currency, many countries, including the United States, now include a watermark, a security fiber, or both in their paper based currency. These security features give the receiver a means to verify a particular note's authenticity. The security fiber is embedded in the paper on which the money is printed, and may include a human readable (albeit small) description of the currency imprinted on its surface.

In addition to fibers, it is known to utilize planchets and particles to authenticate items. These types of authentication mechanisms may be color based, that is, they may have a characteristic color, they may diffract light, or they may fluoresce when subjected to an excitation, for example IR, optical, or UV radiation.

The authentication materials and devices mentioned above, which may also be referred to as taggants, including fibers, planchets and particles, are typically produced to a

specific size and shape that is appropriate for the object with which they will be associated.

A need exists to provide enhanced identification, authentication and encoding capabilities for taggants, which need has not been adequately addressed prior to this invention.

SUMMARY OF THE INVENTION

The foregoing and other problems are overcome by methods and apparatus in accordance with embodiments of this invention.

A method and apparatus for identifying an object are disclosed wherein an item is identified by including selected taggants, where the taggants have discernable physical properties, such as dimensions and/or a loading factor, for identifying the object. The method may also include irradiating the taggants, detecting resulting emissions from the taggants, and identifying the object based also on the emissions.

A set of taggants are provided with members having different and distinguishable physical characteristics, such as one or more of diameter, length, linear dimension(s), shape (e.g., curved versus straight), wavelength emission (or simply color) and loading factor (i.e., number per unit area or unit volume). Selected ones of the taggants are placed on or in a substrate associated with an object of interest, or they may be placed on or in the object itself. The taggants are selected so as to combinatorially encode information regarding the object of interest. By imaging the object or substrate in or on which the taggants are placed, the physical characteristics are obtained and the encoded information is decoded. For example, a tag affixed to an object may include three different types of particles, each emitting at a different wavelength (e.g., green, yellow, red) and each having an associated diameter (which may be

different or the same). In addition, the particles may be present with different loading factors (e.g., 10 per square centimeter, 20 per square centimeter, 50 per square centimeter). The resulting set of physical characteristics or attributes is predetermined to encode information regarding the object of interest, and can be used to identify the object and/or to verify the authenticity of the object.

A method in accordance with these teachings provides information concerning an object, and includes steps of providing the object and encoding information concerning the object by providing a set of taggants in association with the object. The set of taggants contains members having distinguishing physical attributes which may include at least one of color, emission wavelength, size, shape and loading factor which, in combination, are predetermined for encoding information regarding the object. Further steps detect the physical attributes and decode the information from the detected physical attributes by identifying the object based on said detected physical attributes. The set of taggants can include at least one of particles, fibers and planchets.

BRIEF DESCRIPTION OF THE DRAWINGS

The above set forth and other features of the invention are made more apparent in the ensuing Detailed Description of the Invention when read in conjunction with the attached Drawings, wherein:

Figure 1A depicts fibers embedded in a substrate;

Figure 1B shows a cross section of the substrate of Figure 1;

Figure 2 shows a substrate having a coding scheme made up of a number of straight fibers and a bent fiber embedded therein;

Figure 3A depicts particles embedded in a type of flat goods;

Figure 3B shows a magnified cross sectional view of the flat good;

Figure 3C shows a magnified perspective view of a particle;

Figure 4 shows a substrate having a coding scheme made up of a number of fibers with different frequency characteristics and a smart card for storing a digital signature or watermark;

Figure 5 shows a schematic diagram of a detection system to identify and authenticate items in accordance with the invention; and

Figure 6 shows a block diagram of a detector array that is part of the detection system.

DETAILED DESCRIPTION OF THE INVENTION

The invention provides for the use of the specific size, shape, color, emission wavelength, loading factor or other physical characteristics or attributes of one or more taggants to create a coding, identification and authentication capability.

As an example, when utilized for coding, identification and authentication, fibers can be extruded to have various diameters ranging from several microns to, for example, some tens of microns. In addition, fibers may be produced having a cross section that is other than circular, for example, triangular, rectangular, ellipsoidal, etc. Fibers may also be produced having specific lengths. Fibers may also be produced to have an essentially straight or a non-straight (e.g., curved) shape.

Planchets can be manufactured to have different, specific diameters and thicknesses, while particles can be produced, such as by precipitation, to have controlled size ranges and shapes.

In each of the foregoing examples various dyes can be used to impart a color and/or a characteristic emission wavelength when illuminated by light, such as UV light.

In accordance with the teachings herein, by creating specific ranges of physical dimensions a coding scheme can be created. In the case of fibers, for example, the following measurably different diameter ranges (D) may be created, 1-5 microns, 10-15 microns, 20-25 microns, and 30-35 microns. As part of the same example, different lengths (L) can be used, e.g., 1.5mm, 3mm, and 5mm. Furthermore, one or more categories of shape (S) can be created, for example, straight or bent. Using these exemplary physical fiber attributes: three different lengths, four different diameters, and two different shapes, there are $L^{(DS)}$ (3^{4*2}) or 6561 unique combinations of physical attributes that can be used for coding and authenticating. The use of various concentrations or densities (loading factors) of the various fiber types adds even further unique combinations.

A similar coding can be accomplished using particles having controlled size distributions. Materials that maintain their dimensions, including hard polymer materials as well as phosphors, can be used to create powders having particles that are accurately sized. For example, if particles with four different mean radii are used in combination with five wavelength ranges of fluorescence, up to 4^5, or 1024 codes can be created.

Particles are particularly well suited for coding products that retain some of the particles, such as textiles, porous materials, etc. By applying various particle combinations on the product, or on a substrate attached to the product, a post manufacturing code can be created. Although electrostatic attraction may cause these particles to be adequately retained, enhanced binding can be achieved using appropriate materials, for example, a mesh incorporated into the product or binding agents such as starches or hair spray

types of products.

Additional coding combinations can be made by incorporating fluorescence emission or body color into the taggant. With UV excitation, for example, at least five unique wavelength categories or frequency ranges can be created. Combining these five different wavelength categories and three lengths yields L^F, or 3^5 combinations, or 243 codes. Even more codes are possible by combining other attributes, such as diameter and shape. For example, using four diameters and five frequency ranges yields D^F (4^5), or 1024 codes.

In addition, the loading factors of various taggants can be employed as a further variable. For example, there may be a set of taggants having two members, the first comprised of red particles of 50 micron diameter and the second comprised of a red (or green, or blue, or yellow) particle having an 80 micron diameter. The first particles may be present with a loading factor of 20 per square centimeter, while the second particles may be present with a loading factor of 40 particles per square centimeter. By counting the numbers of particles per unit area of each type, one may determine the information encoded by the selected taggants. For example, a paper document having this particular set of taggants is identified as a first type of negotiable instrument, while another paper document having a different set of taggants (e.g., red particles of 25 micron diameter and 80 micron diameter with loading factors of 50 per square centimeter and 100 per square centimeter, respectively) is identified as a second type of negotiable security. Furthermore, one may verify the authenticity of the negotiable security by verifying that the expected set of taggants are actually present with the expected size ranges and loading factors.

Figure 1A shows an example of a substrate 100 having a coding scheme in accordance with the invention. Several fibers 110 having the same length are embedded in the substrate 100. A magnified cross sectional view, as shown

in Figure 1B, shows the fibers 110 as having different diameters. Fiber 110A has a larger diameter, fiber 110B has a smaller diameter, while fiber 110C has an intermediate diameter. Thus, the substrate is coded by the diameters of the fibers 110, and can be authenticated by identifying the diameters of the fibers 110.

Figure 2 shows another example of a coding scheme. A substrate 120 has a number of straight fibers 130 and a bent fiber 140 embedded within. The substrate is coded by, and can be authenticated by, the number of straight and bent fibers.

Figure 3A shows an example of coding and authenticating flat goods. One of a type of flat goods 150 is shown, in this example a towel, having an area 160 where particles 170 have been embedded in the towel. A magnified cross section of the towel 150 is shown in Figure 3B. The towel is preferably made up of layers 180, where one or more layers, for example 108B, 180C, are made of a mesh for retaining the particles 170. Alternatively, one of the layers 180 may be treated with a binding agent as described above for retaining the particles. Figure 3C shows a perspective view of one of the particles 170. The particle 170 preferably includes a characteristic color that identifies the origin of the towel 150. The particle may also include material that when exposed to a specific type of radiation, for example, UV light, fluoresces at a known wavelength, or within a known wavelength range. In addition, the opposing sides 190 of the particle preferably all have the same dimensions. In this example, opposing sides 190A, 190B, and 190C, 190D have dimensions that correspond to the dimensions of the towel 150. For example, where towel 150 may measure 40 inches by 60 inches, opposing sides 190A through 190D may measure 40 microns by 60 microns. Thus the physical attributes, that is the dimensions, of the taggant may be combined with semantic information about an object, in this

example the dimensions of the object, to provide enhanced coding and authentication capabilities.

It should be understood that the shapes of the particles are not limited to a rectangular geometry or any other particular shape. For example, a spherical particle could also be used, as could an elliptically shaped particle.

Figure 4 shows yet another example of a coding and authentication scheme. An unprinted document substrate 200 preferably contains a code that is derived from five unique wavelength categories of fluorescence (F) and 3 fiber lengths (L) creating L^F , or 3^5 combinations or 243 codes.

The decoding or identification of a code employs imaging of the taggants, as well as the detection of fluorescent emission or color if present. This can be achieved, for example, by using a microscope system coupled to a monolithic spectrometer. Another embodiment may use a narrow band filtered detection system including CCD camera based devices. This can be done directly on the object if it is easily manipulated or flat, such as a document, or by removing a number of the taggants and inspecting the particles.

A detection system 300 in accordance with the invention is shown in Figure 5. A source of radiation 310 is directed on an item 320 to be examined. The source 310 preferably generates UV radiation, but may generate any type of radiation that is suitable for detecting the coding scheme included with the item 320 and/or any appropriate attributes of the item 320. The item 320 may be mounted on a positioning device 325 in order to locate the item 320 for irradiation. The positioning device may include a conveyor or any other type of device suitable for transporting or locating the substrate for irradiation. A detector array 330, such as a CCD, with appropriate support circuitry 340 detects an image of the taggants 350 in the item 320. The

source 310 and detector array 330 may also comprise positioning devices (not shown) for locating these devices for optimum performance. In response to being irradiated by the source 310, the taggants 350 in the item 320 may also emit one or more wavelengths associated with the coding scheme. The detector array 330 is preferably capable of detecting the spectral content of any emissions, in addition to any other physical characteristics of the taggants 350 or the item 320 for identification of the coding scheme and authentication of the item 320. Control circuitry 360 directs the activity of the overall system 300, and in particular controls the source 310, positioning device 325, detector array 330 and support circuitry 340.

As shown in Figure 6, the detector array 330 is preferably comprised of an optical section 370 for focusing received emissions within the detector array 330, an array of sensors 380 for detecting the emissions, and a filter section 390 for allowing only the frequencies of interest to impinge on the sensors 380. The optical section 370 may include a microscope system or any other system suitable for magnifying or otherwise focusing the image of the item 320 and/or any emissions from the item 320 within the detector array 330. The sensor array 380 may comprise any array of sensors suitable for detecting the emissions and/or physical characteristics of the item 320, for example, a diode array, a CCD array, etc. Using this technique the output of the detector array 330 is analyzed to detect the various sizes and/or shapes of the taggants so as to derive the encoded information therefrom, either alone or in combination with the emitted wavelength(s).

Although described above in the context of specific substrates, coding mechanism lengths, diameters, shapes, colors, and the like, those skilled in the art should appreciate that these are exemplary and indicative of presently preferred embodiments of these teachings, and are

not intended to be read or construed in a limiting sense upon these teachings.

It can be appreciated that the techniques and structures described above are useful for authenticating objects based on coding mechanisms included in the object. It can also be appreciated that by selecting certain coding schemes described above when constructing items, that the techniques and structures disclosed herein are also useful for encoding various types of information into objects, and authenticating those objects, such as valuables, negotiable instruments, works of art, currency, various types of substrates, items that may require sorting, items that are traveling on a conveyor system, etc.

It can thus be appreciated that while the invention has been particularly shown and described with respect to preferred embodiments thereof, it will be understood by those skilled in the art that changes in form and details may be made therein without departing from the scope and spirit of the invention.

Claims

What is claimed is:

1. A method of identifying an object, comprising the steps of:

encoding an object by providing a set of taggants in association with said object, wherein said set of taggants is comprised of members having discernable physical attributes predetermined for encoding information regarding said object;

detecting said discernable physical attributes; and

identifying said object based on said detected physical attributes.

2. The method of claim 1, wherein said physical attributes comprise at least one of size and shape.

3 The method of claim 1, wherein said physical attributes comprise at least one of color and emission wavelength.

4. The method of claim 1, wherein said physical attributes comprise loading factor.

5. The method of claim 1, wherein said physical attributes are related to one or more dimensions of said object.

6. The method of claim 1, further comprising steps of:

illuminating said set of taggants with radiation; and

detecting at least one emission wavelength from said set of taggants in response to said step of illuminating.

7. The method of claim 6, further comprising the step of at least one of identifying or authenticating said object based on a combination of said at least one detected emission wavelength in combination with at least one of a size or

shape of said taggants.

8. The method of claim 6, further comprising the step of at least one of identifying or authenticating said object based on a combination of said at least one detected emission wavelength in combination with at least one of a dimension or a loading factor of said taggants.

9. The method of claim 6, further comprising the step of at least one of identifying or authenticating said object based on a combination of said at least one detected emission wavelength in combination with at least one of a size or a loading factor of said taggants.

10. The method of claim 6, further comprising the step of at least one of identifying or authenticating said object based on a combination of said at least one detected emission wavelength in combination with at least one of a shape or a loading factor of said taggants.

11. An apparatus for identifying or authenticating an object, comprising:

a detector for detecting physical attributes of a set of taggants associated with said object; and

a decoder for decoding information encoded by said physical attributes for at least one of identifying or authenticating said object.

12. The apparatus of claim 11, wherein said physical attributes comprise diameter.

13. The apparatus of claim 11, wherein said physical attributes comprise length.

14. The apparatus of claim 11, wherein said physical attributes comprise shape.

15. The apparatus of claim 11, wherein said physical

attributes comprise at least one of color or emission wavelength.

16. The apparatus of claim 11, wherein said physical attributes comprise loading factor.

17. The apparatus of claim 11, wherein at least one dimension of at least one of said taggants is related to a physical characteristic of said object.

18. The apparatus of claim 11, and further comprising a source for illuminating said set of taggants, wherein said detector comprises means for detecting at least one emission wavelength in response to the illumination.

19. The apparatus of claim 11, wherein said set of taggants comprise at least one of particles, fibers, and planchets.

20. A method for providing information concerning an object, comprising the steps of:

providing an object; and

encoding information concerning the object by providing a set of taggants in association with said object, wherein said set of taggants is comprised of members having distinguishing physical attributes comprised of at least one of color, emission wavelength, size, shape and loading factor which, in combination, are predetermined for encoding information regarding said object.

21. A method as in claim 20, and further comprising steps of:

detecting said physical attributes; and

decoding said information from the detected physical attributes by identifying said object based on said detected physical attributes.

22. The method of claim 20, wherein said set of taggants

comprise at least one of particles, fibers, and planchets.

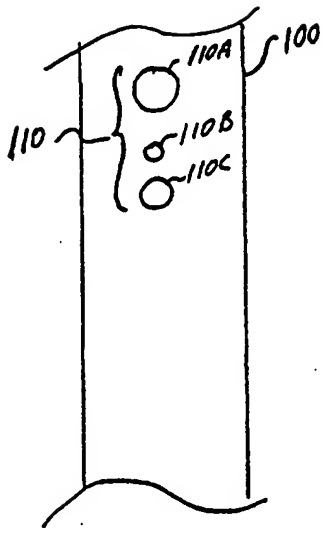


FIG. 1B

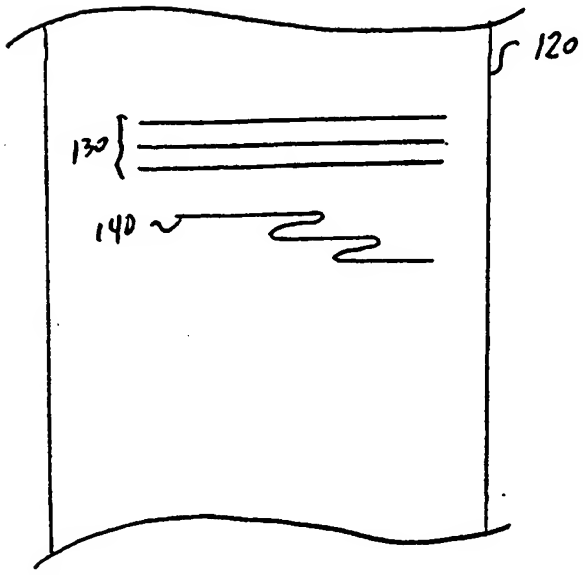


FIG. 2

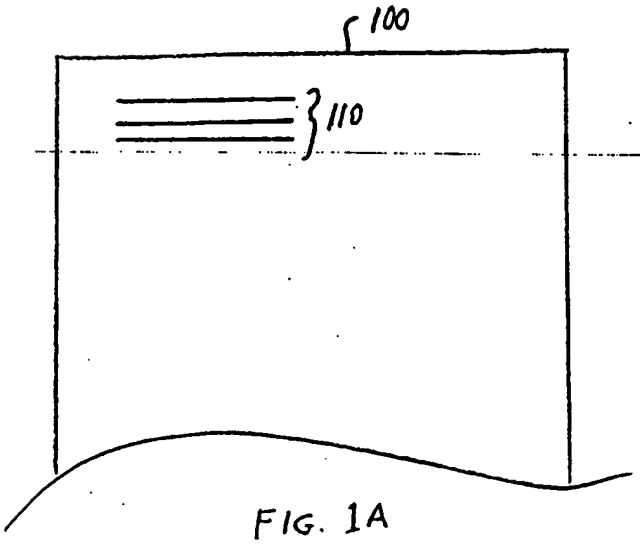


FIG. 1A

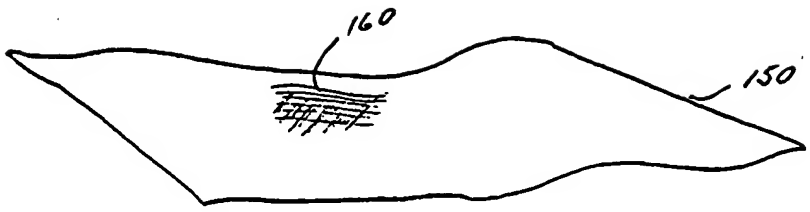


FIG. 3A

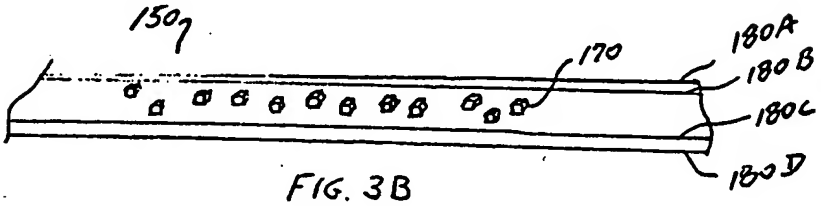


FIG. 3B

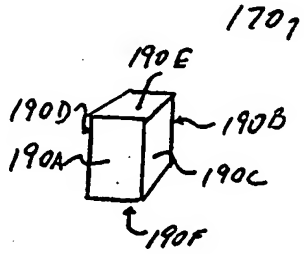


FIG. 3C

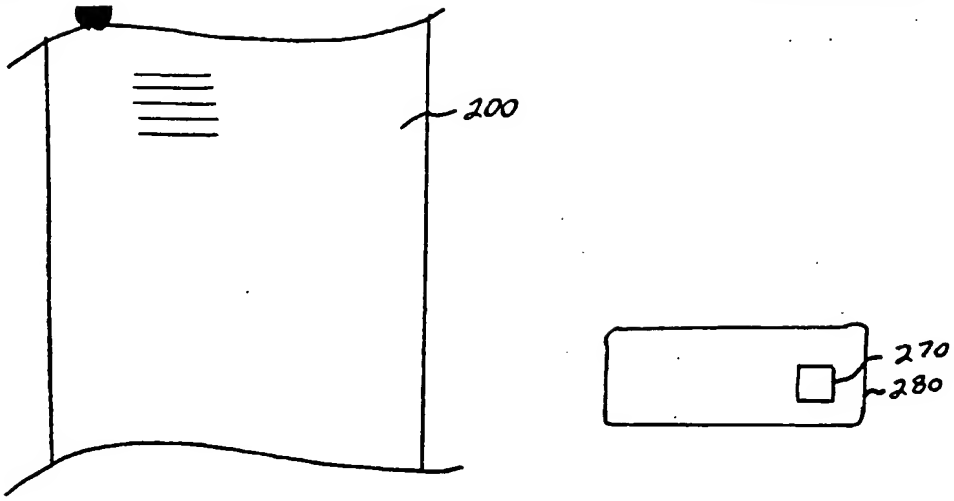


FIG. 4

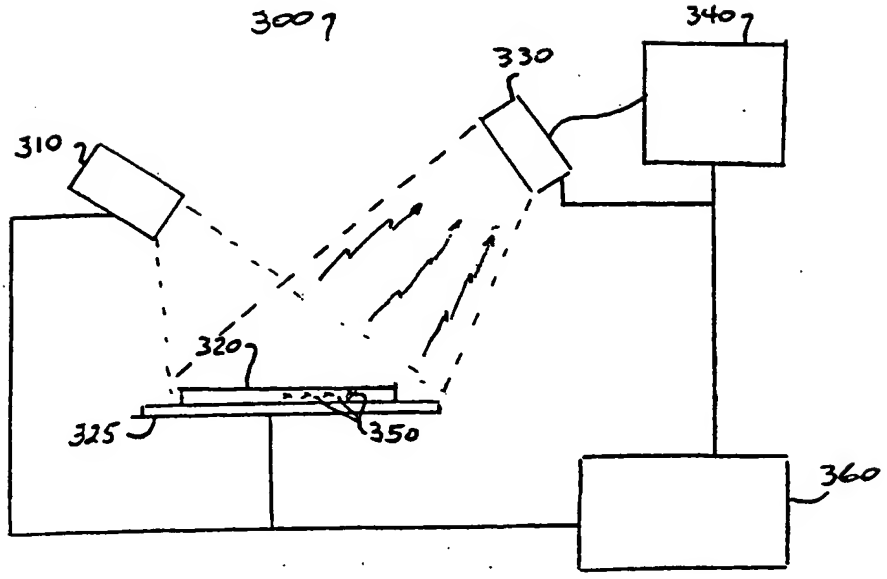


FIG. 5

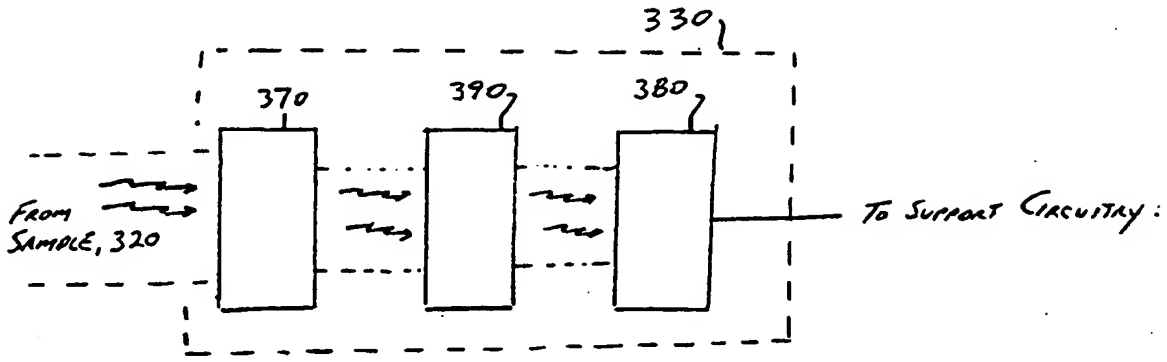


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/42065

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :G06K 9/00; B05D 5/00; G03C 3/00
US CL :382/100, 135, 203; 427/288, 457; 430/9, 39
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 382/100, 135, 203; 427/288, 457; 430/9, 39

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST, IEEE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,131,064 A (RYAN et al) 26 December 1978, col. 2, lines 13-18.	1-22
Y	US 5,225,900 A (WRIGHT) 06 July 1993, col. 5, lines 40-53.	1-22
Y	US 5,543,177 A (MORRISON et al) 06 August 1996, col. 10, lines 3-13.	1-22
Y	US 5,667,924 A (ZIOLO) 16 September 1997, col. 6, lines 34-50 and col. 17, lines 45-54.	1-22

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
22 MARCH 2001

Date of mailing of the international search report
18 APR 2001

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
MATTHEW C. BELLA
Telephone No. (703) 308-6829

Form PCT/ISA/210 (second sheet) (July 1998)*